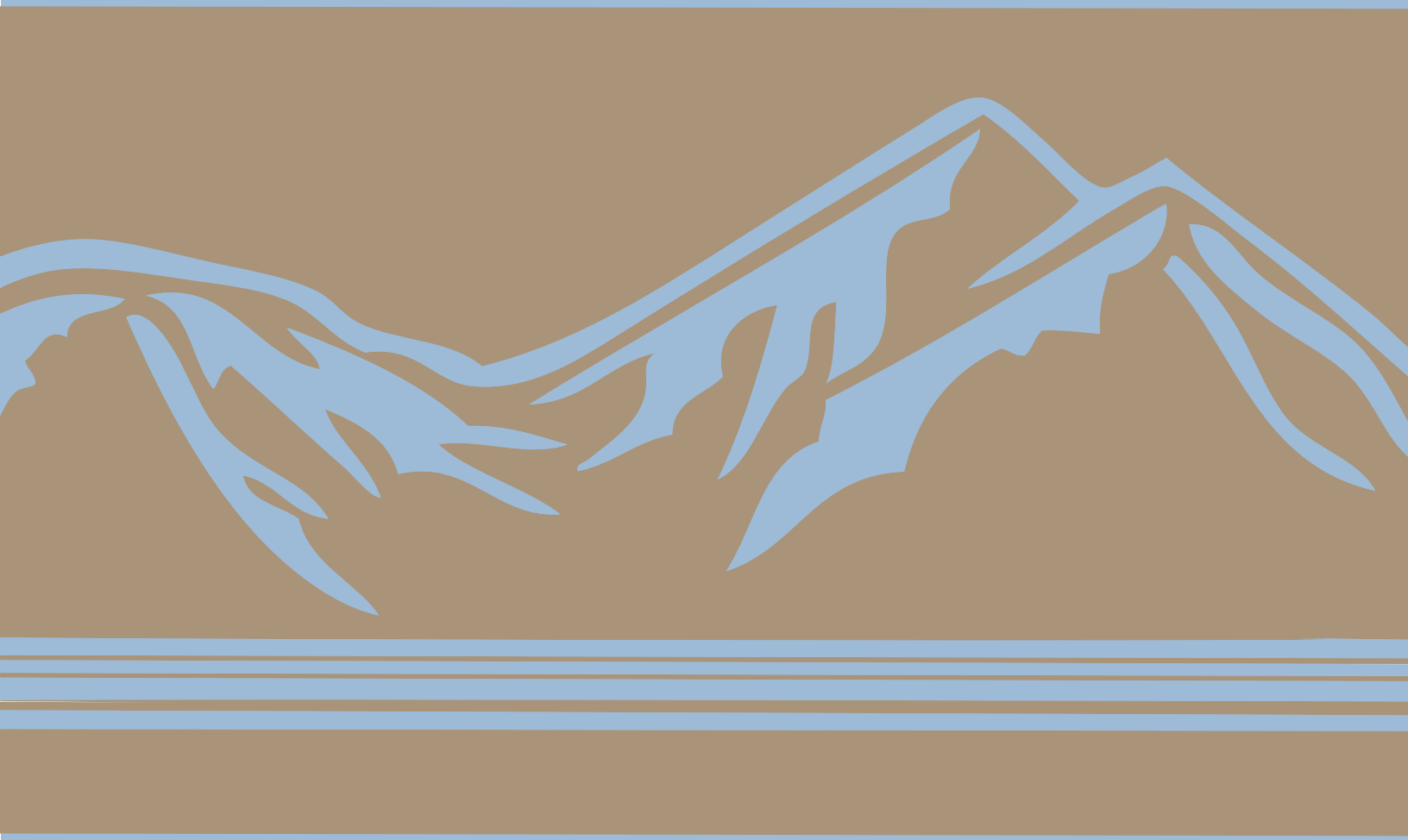
Lower Colorado River Science Symposium

2016



February 8 and 9, 2016

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With additional contributions by

Southern Nevada Water Authority, Western National Parks Association, and UNLV

Western National Parks Association

Details at a Glance

February 8 and 9, 2016 • 9:00 am - 4:30 pm
Southern Nevada Water Authority Colorado River Room
Molasky Corporate Center • Seventh Floor
100 North City Parkway Las Vegas, NV 89106

Don't forget: **Lunch is on your own.**

Parking: Parking tickets can be validated throughout the day at the SNWA Security Desk just outside of the elevators on the seventh floor. Once validated, the ticket is good until you leave the garage.

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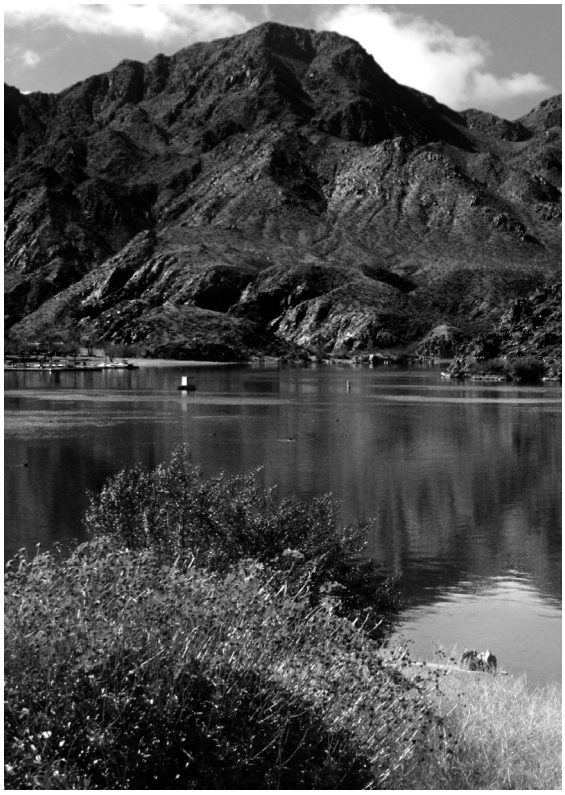
Lower Colorado River Science Symposium 2016

Welcome

The fourth biennial Lake Mead Science Symposium has expanded its focus, evolving into the Lower Colorado River Science Symposium. Within this event, multi-agency/multi-organization staff, scientists, partners, students, and stakeholders gather to hear the latest results and findings. These efforts all converge in the collective endeavor to protect water quality for public and municipal water supply, aquatic life, wildlife, recreation, and other beneficial uses. Aquatic life and wildlife includes all components of the food web, which maintain healthy native and sport fisheries and support aquatic dependent wildlife (e.g., avian species), and extends to sediments and riparian and shoreline-dependent native vegetation. Physical and biological stressors with the potential to disturb the health of the ecosystem are of interest as are activities related to wastewater reclamation. With generous support from the Nevada Division of Environmental Protection and the work of the symposium chair and co-chairs to create a streamlined program focused entirely on presentations, registration for the 2016 Lower Colorado River Science Symposium is free.



Lake Mohave; photo courtesy National Park Service

Symposium Committee

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Kumud Acharya | Desert Research Institute
Heidi A. McMaster | Bureau of Reclamation
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Peggy Roefer | Colorado River Commission
Michael R. Rosen | U.S. Geological Survey
Kent Turner | National Park Service

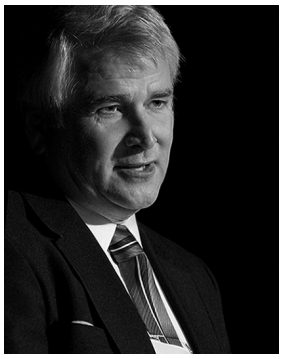
Keynote Address

Colorado River viewed from the Grand Canyon's Toroweap Overlook; photo ©Kojihirano

An overview of the Colorado River

Chris Holdren, Ph.D.
Environmental Consultant

The Colorado River is arguably the most important river in the western states. The major cities in the southwest, including Las Vegas, could not have developed without this valuable resource. This talk will describe the river and its uses from its origin the Rocky Mountains in Colorado to its outfall in the Gulf of California.



Chris Holdren recently retired after careers as the Manager of the Environmental Applications and Research Group with the Bureau of Reclamation in Denver, Colorado; an environmental consultant in the mid-Atlantic states; and as a professor at the University of Louisville in Kentucky. His projects in the western states included water quality-studies of Lake Mead, Arizona-Nevada and the Salton Sea, California. Throughout his career, Holdren has served within a variety of positions for regional, national, and international water science associations, including president of the North American Lake Management Society. With more than 40 years of experience in lake and watershed management programs, Dr. Holdren has resumed his consulting practice on a limited basis. Holdren holds a Ph.D. in Water Chemistry from the University of Wisconsin-Madison.

Agenda

Day 1: February 8, 2016

8:00–9:00	**REGISTRATION OPEN**
9:15–9:20	**Welcome** Todd Tietjen, 2016 Symposium Chair, Southern Nevada Water Authority
9:20–9:30	**Opening Remarks** Lower Colorado Regional Director, Dr. Terry Fulp, Bureau of Reclamation - Invited Lake Mead National Recreation Area Superintendent, Lizette Richardson, National Park Service - Invited
9:30–10:25	**Keynote Address: An overview of the Colorado River** Chris Holdren, Environmental Consultant
10:25–10:40	BREAK
10:40–Noon	**MANAGEMENT ISSUES and APPROACHES**
10:40–11:00	**Partnership to conduct Natural Resource Condition Assessments (NRCA) for Lakes Mead and Mohave** | Turner, K.; Chandra, S.; Ngai-Ryan, C.
11:00–11:20	**Management implications of exposed lands due to drought: Making the hard decisions** | Newton, A.C.
11:20–11:40	**EPA Region 9 Lower Colorado River Geographic Response Plan** | Smith, J.B.
11:40–Noon	**Lake Mead NRA recreation suitability guidelines** | Turner, K.
Noon–1:30	LUNCH (on your own)
1:30–3:10	**WATER QUALITY**
1:30–1:50	**Nutrients in stormwater runoff and distribution in Lake Havasu** | Wilson, D.C.
1:50–2:10	**Lake Havasu conditions during the 2014-2015 *Microcystis* outbreak** Wilson, D.C.; McMaster, H.A.; Kirsch, J.E.; Walker, D.B.
2:10–2:30	**Lake Mead National Recreation Area Monitoring Program – U.S. Geological Survey depth-dependent water-quality profile data** | Orozco, E.; Veley, R.
2:30–2:50	**Regime change in the plankton of Lake Mead? Impacts of higher winter water temperatures** | Beaver, J.R.; Kirsch, J.E.; Renicker, T.R.; Samples, E.E.; Scotese, K.C.; Baldarelli, L.M.; Blasius-Wert, B.J.;Walker, J.T.; Murray, W.D.; Woods, Z.D.; Zimba, P.V.
2:50–3:10	BREAK
3:10–4:30	**BIOLOGIC RESOURCES**
3:10–3:30	**Phytoplankton and zooplankton diversity influenced by tributaries to Lake Mead** | Tietjen, T.
3:30–3:50	**Lower Colorado River Native Fish Database** | Pacey, C.A.; Marsh, P.C.
3:50–4:10	**Marsh Education: A non-profit organization benefitting Arizona's children and native fishes** | Pacey, C.A.; Marsh, P.C.
4:10–4:30	**Distribution of snakes along the Colorado River corridor of the eastern Mojave Desert** | Jones, J.L.; McKeever, R.W.
4:30–4:35	DAY 1 CLOSE

Agenda

Day 2: February 9, 2016

8:00–9:00	**REGISTRATION OPEN**
9:00–9:10	**Welcome** | Todd Tietjen, 2016 Symposium Chair, Southern Nevada Water Authority
9:10–10:25	**INVASIVE SPECIES**
9:10–9:30	**Do leaf beetles alter tamarisk evapotranspiration?** Acharya, K.; Sueki, S.; Huntington, J.; Liebert, R.; Healy, J.
9:30–9:50	**Lake Havasu water quality and quagga mussel monitoring program update** McMaster, H.A.; Kirsch, J.J.; Anat, D.; Maynard, M.M.
9:50–10:10	**Long-term population monitoring for quagga mussels at Lake Mead NRA** Thom, T.; Chandra, S.; Caires, A.; Smith, B.; Gaiz, K.
10:10–10:25	BREAK
10:25–Noon	**CONTAMINANTS and STRESSORS**
10:25–10:45	**Occurrence of organic contaminants in Lake Mead from 2002 to 2014** Alvarez, D.; Rosen, M.; Jones-Lepp, T.; Moran, M.
10:45–11:05	**How evaluations of low concentrations of organic chemical contaminants are important in managing the Lake Mead ecosystem** | Rosen, M.R.; Goodbred, S.L.
11:05–11:25	**Concentration and spatial distribution of whole-body contaminants in common carp of Lake Mead NRA, and biological implications** | Patiño, R.; VanLandeghem, M.M.; Goodbred, S.L.; Orsak, E.; Jenkins, J.; Echols, K.; Rosen, M.R.; Torres, L.
11:25–11:45	**Uptake of pharmaceutical and personal care products (sulfamethoxazole, trimethoprim, and triclosan) by a green alga** | Bai, X.; Acharya, K.
11:45–12:05	**Towards detecting algae using satellite-based remote sensing at Lake Mead** Huntington, J.; Acharya, K.; McGwire, K.; Sappington, M.; Turner, K., Thom, T.; Gaiz, K.; Smith, B.
12:05–1:30	LUNCH (on your own)
1:30–3:10	**EDUCATION, MODELING, and MAPPING**
1:30–1:50	**Lake Mead NRA educates the public and develops future land stewards** Whitesides, H.J.; Senegal, T.
1:50–2:10	**Developing an improved weather forecasting system for Lake Mead NRA** Lericos, T.; Sappington, M.; Foster, N.; Berc, D.
2:10–2:30	**National Weather Service wave and wind modeling efforts over Lake Mead and Lake Mohave** | Czyzyk, S.; Shafer, C.; Steele, C.
2:30–2:50	**Use of Lowrance HDS sonar units on Lakes Mead and Mohave for high-resolution bathymetric mapping** | Gaiz, K.; Sappington, M.; Turner, K.; Smith, B.; Thom, T.
2:50–3:10	BREAK
3:10–4:15	**CLIMATE CHANGE and PREDICTION**
3:10–3:30	**The impact of changing storm properties on water fluxes and solute transport in Las Vegas Valley** | Jiang, P.; Acharya, K.; Chen, L.; Yu, Z.
3:30–3:50	**How long does a fifteen-year drought last? On the correlation of rare events** | Rhee, G.; Grigg, C.
3:50–4:10	**The combined effects of land use and climate change on river and stream salinity in the lower Colorado River Basin** | Olson, J.R.
4:10–4:15	DAY 2 CLOSE

Abstracts

Management Issues & Approaches 8 February

10:40—11:00

Partnership to conduct Natural Resource Condition Assessments for Lakes Mead and Mohave

Kent Turner[1], Sudeep Chandra[2], & Christine (Ka Lai) Ngai Ryan[2] | [1]National Park Service, [2]University of Nevada, Reno

NPS Natural Resource Condition Assessments (NRCAs) evaluate current conditions for important natural resources in parks. Evaluations extend to factors influencing resource conditions as well as critical data and knowledge gaps. Science-based information delivered in NRCAs assist managers in efforts to take integrated and strategic approaches to resource planning and decision making. Science summaries also enhance communication of current resource condition to interested stakeholders and the public. Lake Mead National Recreation Area is partnering with the University of Nevada, Reno to conduct a limnological NRCA for Lakes Mead and Mohave.

This NRCA will report within the environmental framework components of landscape condition, biotic condition, chemical and physical characteristics, ecological processes, hydrology and geomorphology, and disturbance regimes. Existing information will be evaluated for over 25 indicators, with over 60 associated measurements and metrics. These include, for example, limnological measures such as temperature, DO and nutrients, as well as biotic measures such as plankton, invertebrates, and fish. While analyses will consist of previously published information or previously collected data, the project also calls for new information through looking at previously unpublished data, or at data sets in new ways or contexts. One example of such novel information will be quantifying the changes in food web structure over time. Preliminary analysis suggests Lake Mead's fishery is driven from benthic resources in all bays (Las Vegas, Overton, and Boulder Basin). The degree of benthic resource utilization by fishes varies by species and over time. In 2008-09, the fishery was more reliant on benthic resources compared with today.

11:00—11:20

Management implications of exposed lands due to drought: Making the hard decisions

Alice C. Newton | National Park Service

Lake Mead water level has dropped approximately 140 vertical feet since the year 2000, adding about 87,000 acres of new land area requiring management. Depending on terrain, every foot of elevational drop exposes between 10 to 30 feet of new shoreline. Lowering lake levels open up disturbed shoreline habitats for weed invasion, and increase potential for harmful algal blooms and other water-borne pathogens in highly-used coves. Sharp quagga mussel shells on exposed shoreline create additional safety hazards for park employees and visitors. Low water provides uncontrolled recreational access via shorelines to undisturbed habitats and archeological resources that were previously inaccessible. Launch ramps, marina and docking facilities, and lake access roads become more difficult and expensive to build as the water drops. Water intakes and well sites are impacted and may become inoperable. Additional grade control structures are needed in the Las Vegas Wash to manage head-cutting and to protect structures such as the Northshore Bridge. Abandoned high-ground facilities, a "bathtub ring" of mineral deposits, mudflats with trash and denuded shorelines all detract from park scenic values. Decision making and resource allocation is extremely difficult under these operating conditions, and will become even more challenging as lake levels rise and fall in the coming years.

11:20—10:40

EPA Region 9 Lower Colorado River Geographic Response Plan

Jeffery B. Smith | Bureau of Reclamation

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) provides the organizational structure and procedures to prepare for and respond to discharges of oil and releases of hazardous substances, pollutants, and contaminants. As required by the NCP, EPA has been delegated the responsibility for planning for inland spills. The Lower Colorado River Geographic Response Plan (LCR-GRP) is the principal guide for emergency preparedness and response along the Lower Colorado River from Hoover Dam to the U.S./Mexico Border. This plan is consistent with the NCP and is intended to facilitate multi-agency and multi-jurisdictional coordination, communication, and collaboration among local, State, and Federal agencies; Tribal nations; and industry when responding to oil and hazardous material emergencies.

The first Colorado River Area Contingency Plan (ACP) was completed in 1993 and amended in 1997 by the addition of ten designated spill boom deployment site strategies to contain and recover contaminants. A Steering Committee was formed in 2009 to update the 1993 ACP, and Area Committees comprised of local, state, federal, tribal, industry, and non-governmental organization (NGO) representatives were formed for each of the three planning/response Areas:

- Area One – Hoover Dam to Davis Dam
- Area Two – Davis Dam to Parker Dam
- Area Three – Parker Dam to the U.S./Mexico Border

It is important to note that the LCR-GRP is a community plan (not a state or federal plan), and a living document intended to be updated periodically as updated information is provided and additional response and protection strategies are developed for sensitive habitat and natural resources, including fish and wildlife areas and critical economic and cultural resources.

10:40—12 noon

Lake Mead National Recreation Area recreation suitability guidelines

Kent Turner | National Park Service

Over seven million people annually visit Lake Mead NRA; the majority engage in water-based recreation. The annual economic benefit from that recreation exceeds $600 million (Batker et al. 2014). Declining water levels since 2000 have increased potential for development of water based health risks, as well as potential for water conditions that detract from visitor enjoyment. NPS management guidelines direct park managers to identify public health issues and disease potential in parks and reduce or eliminate hazards. EPA's 2011 National Lake Assessment, provides criteria to evaluate "recreation suitability" through measurements protective of human health and safety. The 2003 World Health Organization "Guidelines for Safe Water Recreational Environments" provides indicators and criteria to ensure water based recreation experiences that are "safe, healthy, and aesthetically pleasing."

To evaluate factors related to visitor safety and experience, in light of rapidly changing limnological conditions, in 2014 Lake Mead NRA established Lake Mead NRA Recreation Suitability Guidelines. The guide establishes indicators for recreation suitability, including human pathogens, hazardous algal blooms and toxins, fish tissue contaminants, and aesthetic experience. The guide provides criteria and action thresholds for the various indicators, as well as associated water monitoring to assess indicators. It also outlines management responses and public education necessary when indicator thresholds are exceeded. In 2015, park management utilized the guidelines to respond to the first ever *Microcystis* algal growth to produce toxins at levels warranting public advisory. This presentation provides an overview of the guidelines, indicators, criteria, thresholds, management, and public education responses when thresholds are exceeded.

Water Quality — 8 February

1:30—1:50

Nutrients in stormwater runoff and distribution in Lake Havasu

Doyle C. Wilson | Lake Havasu City and Arizona State University

Lake Havasu, the southernmost of the three largest reservoirs on the Lower Colorado River, sits adjacent to an urban drainage area (112 km^2) larger than itself (78 km^2). Precipitation events occasionally result in stormwater flow draining into Lake Havasu from Lake Havasu City's ten washes. Two of the washes have built small deltas into the lake from runoff events since 2012. The other washes have had perennial vegetative buffers that influence runoff and sediment distribution into the lake.

Runoff water-quality data, including macro nutrients, have been collected from 15 storm events since 2012. Recorded total and ortho-phosphate concentrations have been highly variable (0.04-18 mg/L (ave. 1.30 mg/L) and <0.05-0.78 mg/L (ave. 0.23 mg/L), respectively) as have been nitrate concentrations (0.4-3 mg/L; ave. 1.57 mg/L). Lateral, depth and wash mouth age-related differences are noted among the phosphate concentrations. Although total phosphate and total nitrogen annual loading into Lake Havasu from Lake Havasu City's drainage system is also variable, amounts could exceed 100,000 kg and 200,000 kg, respectively.

Additional sampling in the reservoir, groundwater and shallow sediments across the wash mouth–shoreline interface at seven washes quantifies expected total and ortho-phosphate enrichment in the sediments (ave: 233 and 0.52 mg/kg, respectively) relative to reservoir water (ave: 0.012 and <0.009 mg/L) and groundwater (ave: 1.84 and 0.19 mg/L) environments. Phosphate concentrations of anoxic lake sediments further offshore are similar to shoreline sediments. The relative contribution of local runoff to the lake sediment nutrient reservoir along with up river and internal biological sources still needs to be determined.

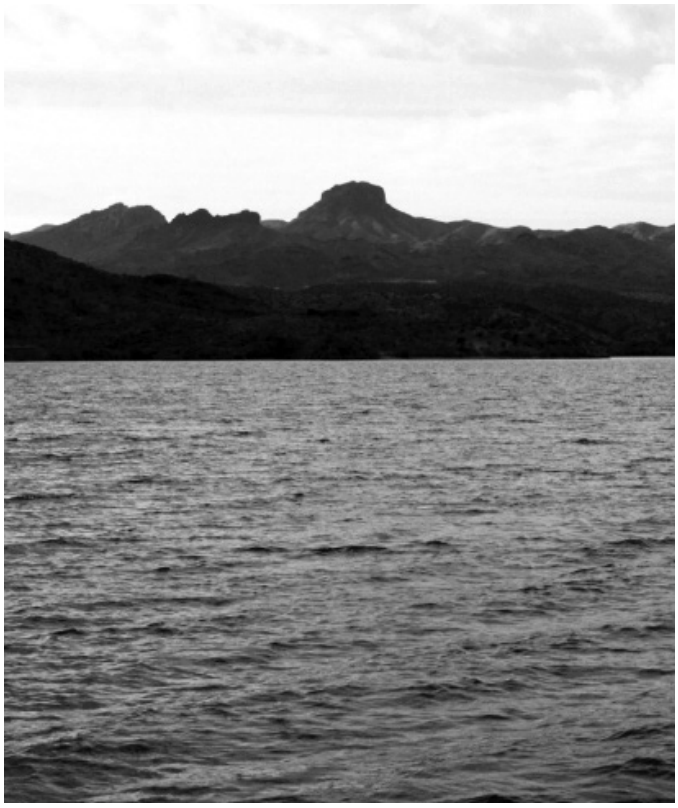
1:50—2:10

Lake Havasu conditions during the 2014-2015 *Microcystis* outbreak

Doyle C. Wilson[1,2], Heidi A. McMaster[3], Janet E. Kirsch[3], & David B. Walker[2] | [1]Lake Havasu City, [2]Arizona State University, [3] Bureau of Reclamation

An unprecedented outbreak of *Microcystis* occurred in the Lower Colorado River in the winter and spring of 2015. Wind-driven *Microcystis* accumulations became noticeable along the California shoreline of Lake Havasu in October 2014 and uniquely continued to expand through the following winter, spring and early summer. Concentrated blooms surrounded by more dispersed colonies slowly drifted down reservoir in the spring and the cyanotoxin, microcystin, was discovered above 1µg/L for the first time in these blooms. Phytoplankton diversity through this period was well represented, yet the biovolumes calculated illustrate that only a few species (e.g., *Microcystis aeruginosa* and *Dinobryon sp.*) were prevalent in the water column.

Causality of the outbreak is speculative, yet winter air temperatures were some of the warmest on record, which kept surface water at its highest February temperature ever measured (16°C). Multi-agency water quality monitoring of the reservoir during the cyanobacteria outbreak provided snapshots of water column physical and chemical characteristics. The reservoir initiated stratification earlier than normal (February), which became well developed by late March. The perceived oligotrophic reservoir conditions would seemingly preclude *Microcystis* outbreak development,



Cupcake Mountain viewed from Lake Havasu; photo by Doyle Wilson.

yet research elsewhere demonstrates that quagga mussels selectively exclude *Microcystis* from its diet, perhaps allowing a competitive advantage to access the limited nutrient supply. Moreover, water column and sediment nutrient data from Lake Havasu provide evidence that phosphate may be released from the anoxic lake bottom and trapped in the hypolimnion during reservoir stratification. In addition, TN:TP ratios in the water column increased over the growth period of the *Microcystis* outbreak and subsequently reversed in the summer as the outbreak was subsiding.

2:10—2:30

Lake Mead National Recreation Area monitoring program – U.S. Geological Survey depth-dependent water-quality profile data

Erin Orozco & Ron Veley | U.S. Geological Survey

The U.S. Geological Survey, in cooperation with the National Park Service, Southern Nevada Water Authority, and Clark County Water Reclamation District, collects depth-dependent water-quality data on Lakes Mead and Mohave within the Lake Mead National Recreation Area (LAKE), Arizona and Nevada. The data are collected as part of a multi-agency monitoring network to provide resource managers with a better understanding of the hydrodynamics of Lakes Mead and Mohave. From 2001 to present, seven depth-dependent water-quality monitoring stations have collected data at locations throughout LAKE. Two of the seven monitoring stations, Boulder Basin (Lake Mead) and Lake Mohave, are still active. The monitoring stations collect water-quality data using automatic-profiling systems equipped with multi-parameter sondes. The sondes have sensors for temperature, specific conductance, dissolved oxygen, pH, turbidity, and depth. Data are collected every 6 hours at 5-meter depth intervals (Boulder Basin) and 2.5-meter depth (Lake Mohave) beginning at 1 meter below water surface. The Boulder Basin monitoring station is also equipped with meteorological equipment that measures wind speed and direction, relative humidity, air temperature, solar radiation, and barometric pressure. Meteorological data is collected on a continual basis and averaged hourly. Water-quality and meteorological data collected for both active and non-active stations can be accessed on-line at http://nevada.usgs.gov/water/lmqw/map.htm.

2:30—2:50

Regime change in the plankton of Lake Mead? Impacts of higher winter water temperatures

John R. Beaver[1], Janet E. Kirsch[2], Thomas R. Renicker[1], Erin E. Samples[1], Kyle C. Scotese[1], Lauren M. Baldarelli[1], Becky J. Blasius-Wert[2], Jeffrey T. Walker[1], William D. Murray[1], Zachary D. Woods[1], & Paul V. Zimba[3] | [1]BSA Environmental Services, Inc., [2]Bureau of Reclamation, [3]Texas A&M University, Corpus Christi, TX

We investigated whether the phytoplankton and zooplankton community composition in Lake Mead displayed any evidence of change from the ca. 2003 invasion of quagga mussels using quarterly data from more than 500 paired phytoplankton and zooplankton samples collected from winter 2007 through fall 2015. Principal component analysis indicated that most of the variance in phytoplankton community structure was explained by two small taxa (*Cyclotella and Rhodomonas*) which are excellent food for the dominant zooplankton grazers (*Daphnia spp.*). Canonical correlation analysis demonstrated the overriding importance of the thermal regime of the system for seasonal initiation and maintenance of the long-established trophic coupling of these small phytoplankton taxa with the major planktonic herbivores despite the invasion of quagga mussels. During the winter of 2014-2015 surface water temperatures averaged approximately 2°C higher than previous winters. Populations of *Microcystis aeruginosa* in 2015 were widely distributed throughout all three basins and well above concentrations found in previous years of the study. During August 2015 the cyanotoxin microcystin was found in more than 80% of the open water samples tested with highest concentrations found in Boulder Basin. One sample taken from a scum at the Las Vegas Boat Harbor exceeded 4600 ppb microcystin. Potential de-coupling of the phytoplankton-zooplankton relationship will be discussed in the context of a projected future of warmer winters and a potentially altered thermal regime.

3:10—3:30

Phytoplankton and zooplankton diversity influenced by tributaries to Lake Mead

Todd E. Tietjen | Southern Nevada Water Authority

The interactions between tributaries and reservoirs have been studied in a variety of contexts. Phytoplankton and zooplankton generally follow similar patterns with low diversity and abundance nearest the inflowing river, increasing in the transitional zone, and then declining in the main body of the lake. Lake Mead offers an interesting opportunity to consider these patterns by comparing the three tributary sources. The Las Vegas Wash carries moderately nutrient rich water to the lake, the Muddy and Virgin Rivers carry less nutrient rich, often more saline water, and the Colorado River carrying sediment rich, cold water to the lake. Simple assessments of algal and zooplankton biomass generally show the strongest response to the nutrients entering through the Las Vegas Wash and the high turbidity of the Colorado River. In this presentation I will evaluate these spatial patterns, and changes in them through time. As with many other limnological phenomena, the size and complex inflow dynamics of Lake Mead make this an interesting system in which to consider these fundamental relationships.

3:30—3:50

Lower Colorado River Native Fish Database

Carol A. Pacey & Paul C. Marsh | Marsh & Associates, LLC

The Lower Colorado River Native Fishes Database (database) maintains native fish stocking and passive integrated transponder (PIT) tag data for lakes Mead, Mohave, and Havasu of the Lower Colorado River Multi-Species Conservation Program, which are defined as Reaches 1, 2 and 3, respectively, and the river below Parker Dam (Reaches 4 and 5). A primary purpose of the database is to support periodic estimation of population abundance of razorback sucker (*Xyrauchen texanus*) in Reaches 2 and 3 in behalf of the species' conservation in the lower Colorado River basin. Based upon adult monitoring data (excluding remote sensing data) from 2014 – 2015, we estimate there is no measurable wild adult population remaining in Lake Mohave, while the repatriated razorback sucker population in that reservoir is estimated to number 2,230 (922–5,963 fish at 95 percent confidence interval). Additionally, we handled data from 40,582 PIT- and wire-tagged, and untagged fish during fiscal year 2015 for all reaches, including data on razorback sucker, bonytail (*Gila elegans*), flannelmouth sucker (*Catostomus latipinnis*) and bluehead sucker (*Catostomus discobolus*), as well as hybrids of razorback sucker and flannelmouth sucker.

Carol Pacey teaching kindergarteners about Arizona native fishes; photo by Abraham Karam.

3:50—4:10

Marsh Education: A non-profit organization benefiting Arizona's children and native fishes

Carol A. Pacey & Paul C. Marsh | Marsh & Associates, LLC

Marsh & Associates, LLC (M&A) traveled throughout Arizona with a pro-active, free, on-site, state-wide public outreach program, *Sharing Tails*, and taught elementary children in kindergarten through second grade about native Arizona fishes, reaching more than 33,000 students from January 2009 through May 2011. We hoped that our program brought attention to the crisis reflected by the fact that a majority of Arizona's native fishes are federally listed or candidate for listing as endangered or threatened or are Wildlife of Special Concern in Arizona. With the cessation of federal funding fiscal year 2012, M&A opted to form Marsh Education, a 501c3 non-profit organization, with the vision that Arizonans will appreciate, respect, and protect native Arizona fishes and the mission to educate Arizona's children about native Arizona fishes. Through our objective to develop funding sources for Marsh Education, we are working toward our goal of providing our *Sharing Tails* program free to Arizona public elementary schools.

4:10—4:30

Distribution of snakes along the Colorado River corridor of the eastern Mojave Desert

Jason L. Jones[1] & Robert W. McKeever[2]
[1]Nevada Department of Wildlife, [2]Desert Herp, Inc.

Using data collected via Quantitative Road Cruising (Rosen and Lowe, 1996) we suggest that topography and vegetative type are key factors in the varied distribution of serpent taxa in the eastern Mojave. Roads in Clark County, Nevada and Mohave County, Arizona were sampled over a fifteen-year period both within, and external to, the Lake Mead National Recreation Area. The data illustrate habitat preferences, and relative abundance within each defined habitat type, of sixteen snake species known to occur in, and adjacent to, the Colorado River corridor.

9:10—9:30

Do leaf beetles alter tamarisk evapotranspiration?

Kumud Acharya, Sueki Sachiko, Justin Huntington, Ryan Liebert, & John Healey | Desert Research Institute

Tamarix spp. (tamarisk or salt cedar) is one of the most common invasive plants in the southwestern United States, occurring in every major watershed. To control tamarisk and potentially increase available water, native enemy *Diorhabda carinulata* (northern tamarisk beetle) was released in several tamarisk dominated riparian systems. Beetles in all stages of their life cycle voraciously feed on foliage resulting in desiccation and eventual loss of leaves from trees. A few studies have been conducted analyzing the effects of beetle defoliation on tamarisk water consumption. However, the question of whether beetles substantially alter tamarisk water consumption is still open for discussion. In this study, post defoliation evapotranspiration (ET) was calculated using the eddy covariance and the White methods. Eddy covariance and groundwater monitoring data were collected in a tamarisk stand along the Lower Virgin River near Mesquite, NV. The beetles arrived at the site in late 2010, and repeated defoliations occurred in 2011 and 2012. Repeated defoliations observed at the site in 2011 and 2012 clearly show that post-defoliation ET values and magnitude of diurnal groundwater-level fluctuations decreased compared with the pre-defoliation values; however, the decrease did not last long. These results were supported by Landsat remote sensing estimates. The study concluded that long-term changes in ET will depend on repeated defoliation occurrences over several years and the ability of tamarisk to withstand beetles' defoliation.

9:30—9:50

Lake Havasu water quality and quagga mussel monitoring program update

Heidi A. McMaster, Janet J. Kirsch, Dana Anat, & Mark M. Maynard | Bureau of Reclamation

Quagga mussels were discovered in Lakes Mead, Mohave, and Havasu in 2007. State regulations authorized by the Aquatic Invasive Species Interdiction Act were put into effect in 2009 and updated in July. In October 2009, Reclamation staff began a pilot study to collect data on quagga mussel veliger abundance. Data collected included secchi disk depth (with and without scope), Eureka multiprobe profiles (temperature, pH, conductivity, dissolved oxygen, and depth), and zooplankton tows. The pilot study established five sampling locations across Lake Havasu. In July 2013, the pilot study shifted from a quagga mussel monitoring study to a more robust water quality monitoring program with the addition of chlorophyll, total phosphorus, and phytoplankton monitoring parameters added in July 2013 and combined inorganic nitrogen added at the May 2014 sampling trip. *Cladocera* species have a greater biomass through the system than the other divisions (50%). Annual Bivalvia averages have remained steady and only account for 2% of the total biomass average. The Bacillariophyta division of phytoplankton accounts for 44% of the total biovolume with Chrysophyta comprising 12%. Chlorophyll a averaged 2.28 mg/m^3 for all locations with July and September having approximately double the averages for all other months in 2014. Total phosphorus averages 0.0077 mg/L throughout the lake; however, phosphorus levels increase an order of magnitude during storm events. Higher chlorophyll levels are directly correlated with water clarity, higher levels leading to decreased water clarity. There does not appear to be a correlation between water clarity and quagga veliger abundance in Lake Havasu. Continuation of the monitoring program is essential to understanding the reservoir and the many variables affecting this ecosystem.

9:50—10:10

Long-term population monitoring for quagga mussels at Lake Mead National Recreation Area

Theresa A. Thom[1], Sudeep Chandra[2], Andrea Caires[2], Ben Smith[1], & Kerry Gaiz[1] | [1]National Park Service, Lake Mead National Recreation Area, [2]University of Nevada, Reno

Since the discovery of quagga mussels (*Dreissena bugensis*) in Lake Mead in January 2007, over 25 federal, state, regional, and local agencies in the Lower Colorado River basin established an interagency monitoring action plan (I-MAP) to assess the quagga mussel population (veligers, juveniles, and adults) and their potential ecological consequences. This presentation summarizes the soft substrate sampling that was a component of the I-MAP monitoring data for adult and juvenile mussels in Lake Mead, and highlights some of the challenges conducting long-term monitoring in a reservoir system.

Beginning in 2009 through the fall of 2015, soft benthic substrates were sampled using a Ponar dredge. Initial sampling occurred in 2009 at seven locations in Lake Mead, (Callville Bay, Gregg Basin, Las Vegas Bay, Overton Arm, Sentinel Island, Temple Bar, and Virgin Basin). The sites varied in water depth from 350 feet to 10 feet. Since 2013, sampling on Lake Mead has been consolidated to two sites (Callville Bay and Las Vegas Bay). Starting in 2012, sampling also included locations on Lake Mohave (Yuma Cove and Tequila Cove). Overall, the dominant sediment types were either silty or rocky substrates. Mean densities of quagga mussels from initial samples collected in 2009 and 2010 will be compared with preliminary sample data from 2013 and 2014 collections.

10:25—10:45

Occurrence of organic contaminants in Lake Mead from 2002 to 2014

David Alvarez[1], Michael R. Rosen[1], Tammy Jones-Lepp[2], & Michael Moran[1] | [1]U.S. Geological Survey, [2]U.S. Environmental Protection Agency

The occurrence of organic contaminants entering Lake Mead has been well documented. Between 2002 and 2014, nine different studies were conducted using passive sampling devices to measure the time weighted average concentrations of legacy and emerging contaminants in and around the Lake Mead National Recreation Area. The passive samplers used were the semipermeable membrane device (SPMD) and the polar organic chemical integrative sampler (POCIS). As part of these studies, a total of 170 individual chemicals were analyzed for, although the lists of chemicals targeted changed somewhat from study to study. These chemicals ranged from legacy organochlorine pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) to emerging chemicals such as fragrances, plasticizers, flame retardants, surfactants, antimicrobials, personal care products, prescription and non-prescription pharmaceuticals, and illicit drugs. Throughout these studies, at least a dozen sites were sampled with Las Vegas Wash, Las Vegas Bay, Boulder Basin, Overton Arm, and Willow Beach being the most frequently sampled. Initial evaluation of the data indicates that many chemicals such as the fragrances and flame retardants have shown a fairly consistent presence over time with regards to occurrence and average concentrations. Comparisons of the findings from each study will be presented to show potential trends in the chemical input into Lake Mead.

10:45—11:05

How evaluations of low concentrations of organic chemical contaminants are important in managing the Lake Mead ecosystem

Michael R. Rosen & Steven L. Goodbred | U.S. Geological Survey

Over the past 30 years, advances in analytical methods and instrumentation have allowed scientists to measure organic contaminant concentrations into the picogram and nanogram ranges. These advances are enabling scientists to source contaminants and determine their pervasiveness in the environment. However, are these low concentrations of contaminants relevant to aquatic and/or human health? In order to address the relevance of low contaminant concentrations to Lake Mead, Nevada, fish health, an interdisciplinary team collaborated to characterize ecosystem responses to a suite of analytes detected at concentrations below established ecological-health criteria. Many of the analytes evaluated do not currently have documented criteria and their potential toxicity is unknown. This presentation examines the correlation between low contaminant concentrations and ecosystem health in Lake Mead, and how the continuing detection of low concentrations of organic compounds measured in water, sediment, and fish in the lake has changed the perception and relative importance of these concentrations in management decisions. The relatively long (21-year) history of studying endocrine disruption in Lake Mead can be used as a model (both positive and negative outcomes) for how results of well-documented scientific studies are used in managing water resources.

11:05—11:25

Concentration and spatial distribution of whole-body contaminants in common carp of Lake Mead National Recreation Area, and biological implications

Reynaldo Patiño[1], Matt M. VanLandeghem[2], Steven L. Goodbred[1], Erik Orsak[3], Jill A. Jenkins[1], Kathy Echols[1], Michael R. Rosen[1], & Leticia Torres[4] | [1]U.S. Geological Survey, [2]Texas Tech University, [3]US Fish and Wildlife Service, [4]Louisiana State University, Baton Rouge

Male common carp were sampled in 2007/08 over a full reproductive cycle from four sites within Lake Mead National Recreation Area: Las Vegas Wash, Las Vegas Bay, Overton Arm, and Willow Beach. Body burdens for 252 contaminants were measured, and biological variables assessed included physiological [plasma vitellogenin (VTG), estradiol-17b (E2), 11-ketotestosterone (11KT)] and organ [gonadosomatic index (GSI)] endpoints. Patterns in contaminant composition and biological condition were determined by Principal Component Analysis, and their associations modeled by Principal Component Regression. Three spatially distinct contaminant gradients were recognized: a mixture typical of wastewaters (PBDEs, methyl triclosan, galaxolide), PCBs, and DDTs. The primary spatiotemporally variable pattern of biological condition recognized consisted of reproductive variables (11KT, E2, GSI). VTG was low in all fish, indicating low estrogenic activity of water. Wastewater contaminants associated negatively with GSI, 11KT and E2; PCBs associated negatively with GSI and 11KT; and DDTs associated positively with GSI and 11KT. Inclusion of sex steroids in the GSI regression on contaminants rendered wastewater contaminants nonsignificant in the model and reduced the influence of PCBs and DDTs. Thus, the influence of contaminants on GSI may have been driven by organismal modes-of-action that include changes in sex steroid production. The positive association of DDTs with 11KT and GSI suggests that lifetime, sub-lethal exposures to DDTs have effects on male carp opposite of those reported by studies using relatively high exposure concentrations. This study highlighted the value of multivariate/multiple regression approaches for exploring

associations between complex contaminant mixtures and reproductive condition in wild fishes.

11:25—11:45

Uptake of pharmaceutical and personal care products (sulfamethoxazole, trimethoprim, and triclosan) by a green alga

Xuelian Bai & Kumud Acharya | Desert Research Institute

Pharmaceutical and personal care products (PPCPs) are known as contaminants of emerging concern in the environment. PPCPs have become an increasing concern in the environment due to their ubiquitous distribution and potential adverse effects to wildlife and human health at parts-per-trillion levels. In Lake Mead ecosystems, the persistence and fate of PPCPs are not clearly understood. This study thus investigated the uptake of PPCPs (i.e., sulfamethoxazole, trimethoprim, and triclosan) by a fresh water green alga, *Nannochloris*. A 14-day incubation study was conducted in the following conditions: algal culture exposed to 12 h light and 12 h darkness cycles; algal culture exposed to no light; and medium with no algal cells. The results showed that triclosan was removed by the algae very rapidly due to binding to the algal cells. Sulfamethoxazole and trimethoprim were not removed by the algae to a large extent compared to triclosan, and they were not found attached to the algal cells. Therefore, algae can play a significant role in the uptake of hydrophobic organic compounds from water, and sorption is the predominant pathway.

11:45—12:05

Towards detecting algae using satellite-based remote sensing at Lake Mead

Justin Huntington[1], Kumud Acharya[1], Kenneth McGwire[1], Mark Sappington[2], Kent Turner[2], Theresa Thom[2]

[1]Desert Research Institute, [2]National Park Service

Hazardous algal blooms are an increasing phenomenon in freshwater systems in North America and other parts of the world. Over the past several years, microcystis algae has been detected in limited quantities in Lake Mead during routine testing. However, in 2015 this algae appears to have overwintered in larger abundances than previously seen and appears to have begun producing algal toxins in the spring. With increasing concern over possible toxic algal blooms across the country, several efforts are taking place at the national level to develop remote sensing tools and early warning systems for water resource managers to better respond to potential algal blooms. The National Park Service along with the U.S. Bureau of Reclamation and Southern Nevada Water Authority (SNWA) have partnered with Desert Research Institute (DRI) to explore and potentially develop a tool using satellite imagery to assist with local efforts to understand and better manage responses to possibly increasing algal events. Historic and contemporary data on turbidity and chlorophyll a from the SNWA database are being correlated with Landsat and Modis satellite imagery, and new field data, including turbidity, chlorophyll a and phycocyanin is being collected through 2015 and mid 2016 on dates that Landsat overflights occur. DRI is using these data to develop algorithms that would allow production of whole lake predictive maps of algal abundance. Challenges include the dynamic nature of algal events that occur on Lakes Mead and Mohave, spatial and temporal resolution of satellite imagery, and limited spectral bands of available imagery.

Education and Modeling — 9 February

1:30—1:50

Lake Mead National Recreation Area educates the public and develops future land stewards

Heather J. Whitesides & Taylor Senegal | National Park Service

In the summer of 2015 Lake Mead National Recreation Area partnered with Great Basin Institute and established an aquatic invasive species (AIS) internship program. Program goals were to slow the spread of AIS to other bodies of water, educate the public on what they can do to prevent the spread of AIS, and develop future land stewards who will enter the workforce. The program consisted of a team of 13 individuals who varied in age, education, and experience. All were given various opportunities to learn about the mission of the National Park Service (NPS), as well as the roles the NPS plays in the preservation and protection of natural resources. The team served as both resource managers and educators by researching and understanding the delicate relationship between native and invasive species, then using their knowledge to educate the public on methods to slow the spread of AIS. This blended position promoted over 35,000 contacts made through formal and informal education on the launch ramps, visitor center, public libraries, and community events. In addition to educating the public, the team was provided opportunities learn more about what future careers in public land may interest them. This learning process included surveying and monitoring native plants, water quality sampling, and creating curriculum based on the Next Generation Science Standards (NGSS).

1:50—2:10

Developing an improved weather forecasting system for Lake Mead National Recreation Area

Todd Lericos[1], Mark Sappington[2], Nathan Foster[1], & Dan Berc[1] | [1]National Weather Service, [2]National Park Service

The National Park Service and National Weather Service have partnered to develop a system to provide improved weather data collection and forecasting for the Lake Mead National Recreation Area. This system will include nine new ground-based weather stations located around the park along with five weather buoys which will be located strategically on both Lakes Mead and Mohave. Weather data from the ground-based stations and buoys will be used by the National Weather Service to develop more detailed weather forecasts and marine specific warning services for the Recreation Area. Additionally, wave data from the buoys will be used to develop computer-based models that will provide up to 48-hour forecasts of wave heights and direction for Lakes Mead and Mohave. Information will be provided to the public through web sites, local television news forecasts, and potentially apps and kiosks located in marina stores. These improved forecasts will allow park visitors to better plan recreational activities and park employees, personnel from other agencies, and researchers to better plan field work around the park and on the lakes, improving visitor experiences, safety, and logistical efficiency. In addition, raw and near real-time data from the weather stations and buoys will be accessible on-line through NOAA and National Weather Service web portals. These data will be valuable for a variety of agency and research projects. This project was funded by the Southern Nevada Public Lands Management Act with additional contributions by the National Weather Service and the National Park Service entrance fee program.

2:10—2:30

National Weather Service wave and wind modeling efforts over Lake Mead and Lake Mohave

Stanley Czyzyk, Chad Shafer, & Caleb Steele
National Weather Service

The National Weather Service Forecast Office in Las Vegas, Nevada is investigating the use of SWAN (Simulating Waves Nearshore) Model to provide wave forecasts over Lake Mead and Lake Mohave. Forecasts from the SWAN will be coupled with and driven by high resolution wind forecasts. The goal of the project is to provide detailed graphical forecasts to core partners and the general public via the Internet and additional dissemination paths.

2:30—2:50

Use of Lowrance HDS sonar units on Lakes Mead and Mohave for high-resolution bathymetric mapping

Kerry Gaiz, Mark Sappington, Kent Turner, & Theresa Thom
National Park Service

Sonar technology has improved significantly over the past several years, and current commercial fish-finding sonar units now have capabilities only offered on units costing tens of thousands of dollars or more just a short time ago. The National Park Service is currently using Lowrance HDS sonar units on many of its vessels on lakes Mead and Mohave to provide not only depth finding capabilities, but also side-scan sonar functionality. Even more powerfully, data from these sonar units can be collected and saved on standard memory cards and post-processed with BioBase, an on-line software subscription service which provides several high-resolution products, including detailed bathymetric maps, depth contours, underwater vegetation maps, and information on bottom hardness. Additionally, change detection analyses can be conducted using data collected at different time periods. Products also include detailed quality control information to assess accuracy and improve future data collections. To date, the park has used these units to create high-resolution bathymetric maps of marina and launch ramp areas on Lake Mead for planning and design in preparation of facility projects to deal with lowering lake levels. However, possible future projects include bathymetric mapping of Lake Mohave, mapping of substrate hardness relative to quagga mussel colonization densities, and underwater vegetation monitoring for invasive species.

Climate Change and Prediction — 9 February

3:10—3:30

The impact of changing storm properties on water fluxes and solute transport in Las Vegas Valley

Peng Jiang[1], Kumud Acharya[1], Li Chen[1], & Zhongbo Yu[2]
[1]Desert Research Institute; [2]University of Nevada, Las Vegas

Changes in climate are likely to induce changes in precipitation characteristics including intensity, frequency, duration and patterns of events. Previous study has indicated that precipitation in Las Vegas Valley will exhibit a changing pattern with shorter storm duration, longer interstorm period, and higher storm intensity. These changes may have profound

impacts on surface water fluxes and solute transport in arid area. In this study, the impacts of changing storm properties on water fluxes and solute transport will be investigated in Las Vegas Valley. Using hourly NOAA precipitation data at McCarran Airport Las Vegas as base data, we will generate a control precipitation time series with projected trend of storm properties using a stochastic precipitation model (only changes in storm properties, no changes in precipitation totals). The generated precipitation and observed precipitation will be used to driven the HYRDUS-1D for the simulation of water flow and chloride transport in selected soil texture and root density distribution. Different responses of water flow and chloride transport will be presented for the impact studies in the study region.

3:30—3:50

How long does a fifteen-year drought last? On the correlation of rare events

George Rhee & Corwin Grigg | University of Nevada, Las Vegas

Drought is one of the most dangerous aspects of climate change. The solution to the problem of water supply in arid regions of the world lies in a quantitative understanding of fluctuations. The methods presented here are relevant to any river system but we illustrate them using the Colorado River. We present a method for estimating the length and severity of a drought, in particular a drought that is already underway. Tree-ring records can be used to estimate yearly fluctuations in Colorado River streamflows for the past 1200 years. These fluctuations have a known dependence on frequency. Here we present estimates of the risk of drought using a mathematical model based on these data. We give a lower limit for the projected length of the current drought. We find that stored reserves of Colorado River water are inadequate to compensate for a drought that we predict will continue for at least another decade. We therefore need to rapidly reevaluate the way we use and store Colorado River water.

3:50—4:10

The combined effects of land use and climate change on river and stream salinity in the lower Colorado River Basin

John R. Olson | Desert Research Institute

Agricultural and urban development have increased salinity in streams and rivers of the lower Colorado River Basin (CRB), but how future development might interact with climate change is unknown. We developed two empirical models to estimate salinity at the end of this century. The first model predicts natural background specific electrical conductivity (EC, a measure of salinity) from static (e.g., geology and soils) and dynamic (e.g., climate and vegetation) environmental factors. The second model predicts deviation from natural background EC as a function of land use and its interaction with natural factors. The first model explained 78% of the variation in EC among minimally impacted sites and the second model explained 60% of the variation in deviation from natural background. We predicted EC at end of the century by replacing climate and land use with published projections of future conditions based on the global climate model A2 emissions scenario. By end of century, EC in streams and rivers of the lower CRB is expected to increase 613 microS/cm on average with over 50% of streams more than doubling their EC. However, most of the change is due to development, with climate change accounting for less than 35% of the increase on average. Although salinity control projects in the CRB have successfully maintained EC, continued development exacerbated by climate change will increase salt concentrations and require even greater control efforts.

Lake Mead; photo courtesy National Park Service.